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ATTENTION IN THE PIGEON: TESTING FOR EXCITATORY AND INHIBITORY CONTROL BY THE WEAK ELEMENTS[1]

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In two experiments, pigeons were trained on a successive discrimination between a color and either a compound S+ or a compound S− consisting of a form superimposed on a second color. Two stimulus control tests followed discrimination training: an attention test in which the form and colors used in training were presented singly and in combination, and then a resistance-to-reinforcement test using the form element of S+ or S− and a novel form. In the attention test, the birds trained with a compound S+ responded most to the S+ compound, less to the S+ color alone, and still less to the S+ form on a dark key. Few responses were made to the negative stimulus, either alone or with the S+ form added. The birds trained with a compound S− pecked most at the S+ color and to a compound of the S+ color with the S− form added. The resistance-to-reinforcement test showed that the birds trained with a compound S+ responded more to the S+ form than to a novel form. However, the birds trained with a compound S− did not reliably respond more to a novel form than to the S− form. These findings suggested that the form element of a compound S+ gains some excitatory control, but the form element of a compound S− does not acquire inhibitory control. The possibility existed that low levels of responding to the S+ form on a dark background in the first experiment were due to use of a darkened key to separate S+ and S− periods during discrimination training. However, the essential findings were the same in a second experiment in which darkening of the chamber separated S+ and S− periods.

Key words: attention, excitatory control, inhibitory control, compound stimuli, discrimination, pigeons

In a well-known experiment on attention in pigeons, Reynolds (1961) presented two compound stimuli in a successive discrimination. The positive stimulus (S+) was a white triangle on a red background, and the negative stimulus (S−) was a white circle on a green background. In a test where the elements of the compounds were presented separately (red, green, triangle on a dark background, circle on a dark background), the pigeons responded to only one of the elements of the positive stimulus compound and responded very little, if at all, to the other element. One pigeon responded to red but not to the triangle, and the other responded to the triangle but not to red. Neither pigeon responded to either element of the negative stimulus compound. Reynolds concluded that "the present results show that a pigeon may attend to only one of several aspects of a discriminative stimulus" (p. 208).

Farthing and Hearst (1970), in an experiment using additional tests of stimulus control, questioned Reynolds' conclusion. Pigeons were trained on a discrimination in which the positive stimulus was a vertical white line on a blue background and the negative stimulus was a horizontal white line on a green background. In addition to presentation of the elements singly during an attention test, the elements were presented together in all possible combinations of line and color. Of the three stimulus displays evoking the greatest number of responses, the birds responded most to blue with a vertical line, next most to blue alone, and least to blue with a horizontal line. The finding that blue alone was responded to less than blue with a vertical line (S+) suggests that the vertical line (S+ form) had acquired excitatory control. The finding that blue with a horizontal line was pecked at less than blue alone suggests an inhibitory effect of the horizontal line (S− form) but is not

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conclusive because the generalization gradient among the three most-responded-to stimuli was not assessed. It could be that the novel compound of blue with a horizontal line produced greater generalization decrement than did blue alone.

Reynolds' basic procedure was repeated in a study by Wilkie and Masson (1976), using either a triangle on a red key or a circle on a green key as the positive stimulus for different birds. If red with a triangle was S+, green with a circle was S− and vice versa. When elements from the compounds were presented singly, the birds responded primarily to the color element of the S+ compound, and few responses were made to the form element of S+ or to either the color or form associated with S−. In addition to the attention test, Wilkie and Masson gave a resistance-to-reinforcement test using the circle and triangle as stimuli. The latter test has been recommended by Hearst, Besley, and Farthing (1970) as a procedure for detecting differences when test stimuli control very little responding and, thus, is particularly suitable for measuring inhibitory control. During the resistance-to-reinforcement test, most of the pigeons responded more to the form associated with S+ than to the form associated with S−. However, the experiment did not address the question of whether the differences in the resistance-to-reinforcement test were due to (a) excitatory control by the S+ form, (b) inhibitory control by the S− form, or (c) some combination of the two.

Attention was studied in the present experiments using both combined cues and resistance-to-reinforcement tests. A feature of the procedure was that only one of the training stimuli, either S+ or S−, was a form-color compound, thus allowing use of another similar novel form during the resistance-to-reinforcement test to independently assess excitatory and inhibitory control by the forms.

EXPERIMENT 1

Method

Subjects

Twelve experimentally naive Silver King pigeons were maintained at approximately 80% of free-feeding weight throughout the experiment. Water and grit were continuously available in the home cages.

Apparatus

A Lehigh Valley Electronics two-key pigeon chamber measuring 32 cm long, 36 cm high, and 35 cm wide was employed. The 2.5-cm-diameter left key was 25 cm from the floor and 8.5 cm from the center of the panel; it was operated by a force of approximately 0.15 *N*. An Industrial Electronics In-Line Display Projector mounted directly behind the response key permitted illumination of the key by red, green, a white equilateral triangle with a 1.1-cm base, a white circle 1 cm in diameter, or a combination of these. The lower edge of the feeder aperture (6 × 5 cm) was 10 cm from the floor. Mixed grain was available for 5 sec during feeder operations. A 2.8-W lamp centrally mounted 33 cm from the floor of the chamber provided continuous illumination, except during feeder operations. White noise in the room masked extraneous sounds. Scheduling and data recording were accomplished with electromechanical circuitry in an adjacent room.

Procedure

All birds were magazine trained, a key-pecking response was manually shaped, and approximately 50 reinforcers were provided on a schedule of continuous reinforcement prior to the first phase of the experiment.

During the first phase, all birds received 20 sessions of discrimination training. For Birds 1, 2, 3, and 4, pecks at the key illuminated with a white triangle superimposed on a red background (S+) were reinforced with a 5-sec grain presentation according to a variable-interval (VI) 60-sec schedule; pecks at the key illuminated green (S−) had no programmed consequences. The S+ and S− periods were 80 sec in duration, alternated regularly, and were separated by a 5-sec period when the response-key was darkened and grain was unavailable. The houselight was illuminated throughout the sessions except during feeder operations when the magazine light provided the sole illumination. Birds 5 through 12 received identical discrimination training except for the stimuli employed as S+ and S−. For Birds 5, 6, 7, and 8, S+ was a red key and S− was a white triangle on a green background. For Birds 9 and 10, S+ was a white circle on

a green background and S− was a red key. For Birds 11 and 12, S+ was a green key and S− was a white circle on a red background. Daily sessions terminated immediately following completion of 16 S+/S− cycles.

The second phase consisted of three sessions. During the first and third sessions, the colors and form to which each bird had been exposed during discrimination training were presented both singly and as form-color compounds. Thus, Birds 1 through 8 were presented with red-alone, green-alone, triangle-alone, red-plus-triangle, and green-plus-triangle; Birds 9 through 12 were presented with red-alone, green-alone, circle-alone, red-plus-circle, and green-plus-circle. Each stimulus and stimulus compound was presented 6 times per session with each presentation lasting 30 sec. The response-key was darkened for 5 sec between presentations of the displays. The order of the displays was random with the restriction that each display occurred once in each block of five stimulus presentations. No grain was available during either of these attention-test sessions. During the second session of this phase, each bird worked on the discrimination to which it had been exposed during the discrimination training phase.

The third phase consisted of a resistance-to-reinforcement test which lasted one session. All birds were presented with the white circle and the white triangle in strictly alternating 80-sec periods, and pecks at both stimuli were reinforced with presentations of grain for 5 sec according to a VI 60-sec schedule. Stimulus periods were separated by 5-sec periods during which the response-key was darkened and grain was unavailable. For Birds 1, 2, 5, 6, 10, and 12, the resistance-to-reinforcement test began with presentation of the white triangle; for Birds 3, 4, 7, 8, 9, and 11, the session began with the white circle. The session terminated following 16 presentations of each stimulus.

Results

Discrimination Training

Table 1 shows the mean number and range of responses to S+ and S− over the last five sessions of discrimination training for each bird. Though individual differences in responding were apparent, the overlap in values among stimulus conditions suggests that these differences were not due to the stimuli used as S+ and S−. For all birds, pecking at the end of discrimination training was almost exclusively confined to the stimulus or stimulus compound associated with reinforcement.

Attention Test

Figure 1 presents total pecks at red, green, red-plus-triangle, green-plus-triangle, and the white triangle alone for the first (open bars)

Table 1

Mean number and the range of responses to S+ and S− over the last five sessions of discrimination training for each pigeon in Experiment 1 and Experiment 2.

Subject	*Training stimuli*[a]	*S+ Responses*	*S+ Range*	*S− Responses*	*S− Range*
EXPERIMENT 1					
P1	RΔ+,G−	1626.2	1496-1804	6.4	0-25
P2	RΔ+,G−	1248.0	1060-1393	22.6	1-47
P3	RΔ+,G−	1881.6	1823-1944	0.2	0-1
P4	RΔ+,G−	1704.0	1618-1775	6.8	0-18
P5	R+,GΔ−	1519.2	1403-1681	0	0
P6	R+,GΔ−	1846.4	1716-1991	1.4	0-4
P7	R+,GΔ−	1787.8	1383-1989	0.8	0-4
P8	R+,GΔ−	1314.2	1240-1433	6.8	0-16
P9	GO+,R−	1307.6	1203-1401	10.2	0-24
P10	GO+,R−	1146.4	1039-1292	0	0
P11	G+,RO−	1895.6	1673-2026	25	5-48
P12	G+,RO−	1370.2	1248-1488	7.6	0-21
EXPERIMENT 2					
P15	GO+,R−	1861.6	1835-1899	41.6	3-104
P16	GΔ+,R−	1362.2	1299-1561	11.4	4-24
P17	RO+,G−	1831.8	1640-1942	2.0	0-5
P18	RΔ+,G−	1259.0	1205-1281	0.2	0-1

[a]R, G, Δ, and O refer to red, green, white triangle, and white circle, respectively; RΔ = compound stimulus with the triangle superimposed on a red background, GO = white circle on green background, etc. Pluses and minuses identify the positive and negative stimuli. See text for details.

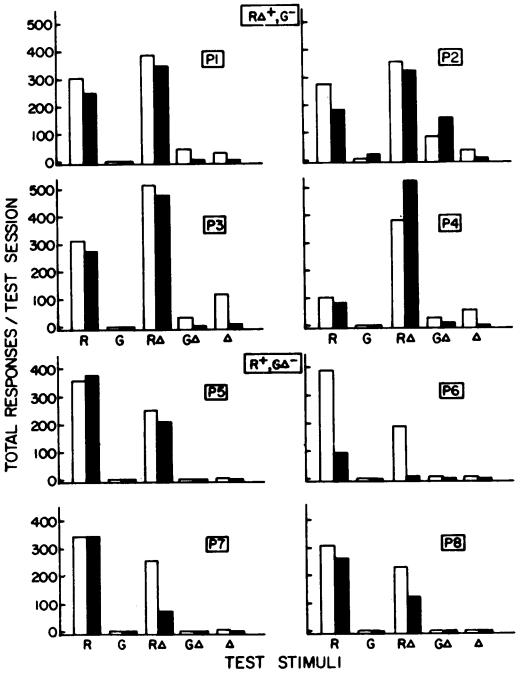

Fig. 1. Total responses recorded during each attention-test session for Birds 1 through 8 as a function of test stimulus-displays. Upper panels present results from birds trained on a red-plus-triangle (S+) versus green (S−) discrimination. Lower panels present results from birds trained on a red (S+) versus green-plus-triangle (S−) discrimination.

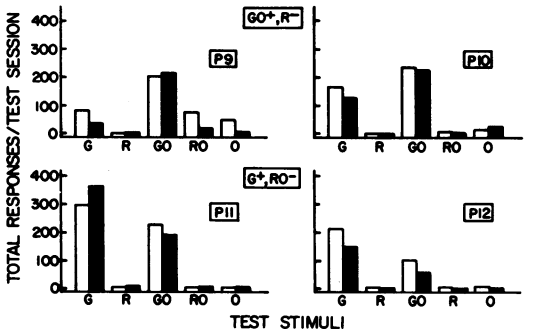

Fig. 2. Total responses recorded during each attention-test session for Birds 9 through 12 as a function of test stimulus-displays. Upper panels present results from birds trained on a green-plus-circle (S+) versus red (S−) discrimination; lower panels present results from birds trained on a green (S+) versus red-plus-circle (S−) discrimination.

and second (solid bars) attention tests for Birds 1 through 8. The results for Birds 1, 2, 3, and 4, originally trained with the red-plus-triangle compound as S+ and green as S−, are presented in the upper portion of the figure. The results for Birds 5, 6, 7, and 8, originally trained with red as S+ and the green-plus-triangle compound as S− are presented in the lower portion.

Although birds generally pecked at the displays less during the second test session than during the first, the pattern of results was essentially the same for both sessions. Birds 1, 2, 3, and 4 pecked more at the original S+ compound, red-plus-triangle, than any other stimulus. When the elements of the S+ compound were separately presented, red-alone was pecked at more than the triangle alone, thus showing that the S+ color was dominant in gaining stimulus control. All of these birds did, however, respond to the triangle, though only Birds 2 and 3 did so during the second test session, and overall responded more to the triangle than did Birds 5 through 8 for whom the triangle was an element of S−. In addition, while green alone (S−) was pecked at only by Bird 2, each of Birds 1 through 4 pecked when the triangle was superimposed on green. Removing the triangle from the original S+ compound, i.e., presenting red-alone, resulted in decreased pecking relative to red-plus-triangle for each of the birds. Thus, color was dominant but the form element of the S+ compound also acquired stimulus control.

Birds 5, 6, 7, and 8 responded almost exclusively to the original S+, i.e., red-alone, and to the red-plus-triangle compound. For all of these birds, superimposing the triangle on red produced decreased pecking relative to red alone which may indicate that the triangle element of S− acquired inhibitory properties or may be an instance of generalization decrement between red-alone and red-plus-triangle. The resistance-to-reinforcement test was conducted to assess these alternatives.

Figure 2 presents the attention-test results for Birds 9 through 12, which were included in the study to ensure that the findings were not specific either to the form employed or to the use of red as S+ and green as S−. Accordingly, Birds 9 through 12 were trained with green as the S+ color, red as the S− color, and a circle (rather than a triangle) as the form element of S+ (Birds 9 and 10) or S− (Birds 11 and 12).

The results of the attention tests were similar to those for Birds 1 through 8. Birds 9 and 10 replicated the data of Birds 1 through

4. Both birds responded more to the original S+ compound, green-plus-circle, than any other stimulus. Green alone was pecked at more than the circle alone showing that color was dominant in acquiring stimulus control, but green was pecked less than green-plus-circle showing that the form had also acquired some control. In addition, both birds responded to the circle in both test sessions and pecked more at red with the circle superimposed than at red-alone (S−), though, for Bird 10, this difference was slight and confined to the first test session. Birds 11 and 12 replicated the data of Birds 5 through 8. Both birds responded almost exclusively to green alone (S+) and the green-plus-circle compound. Adding the circle to green produced a decrement in responding relative to green alone.

Resistance-to-Reinforcement Test

The number of responses during each presentation of the triangle and circle in the resistance-to-reinforcement test is presented in Figure 3 for Birds 1 through 4 and in Figure 4 for Birds 5 through 8. Bars to the right of each panel show total responses to each stimulus over the test session. These tests were conducted to compare resistance-to-reinforcement of the form element of S+ or S− with resistance-to-reinforcement of a novel stimulus.

Figure 3 shows that Birds 1 through 4 responded more to the triangle (S+ form) over the test session than to the circle (novel form) indicating that the form element of the S+ compound acquired excitatory stimulus control. Birds 3 and 4 consistently pecked more at the triangle than the circle from the outset of the test and Bird 1 demonstrated consistent differential responding following the sixth presentation of the triangle. For Bird 2, the difference in pecking at the triangle and circle was very slight and was not reliable between successive stimulus presentations.

The results for Birds 5 through 8, presented in Figure 4, were not consistent and provided little evidence that the form element of the S− compound acquired inhibitory control. Birds 5 and 6 responded more to the circle (novel stimulus) than to the triangle (S− form) over the session but, for Bird 5, this difference was very slight and unreliable between successive stimulus periods, and for Bird 6, the difference occurred reliably only during the first third of the session. Birds 7 and 8 responded more to the triangle than to the circle over the test session. For Bird 7, this difference was

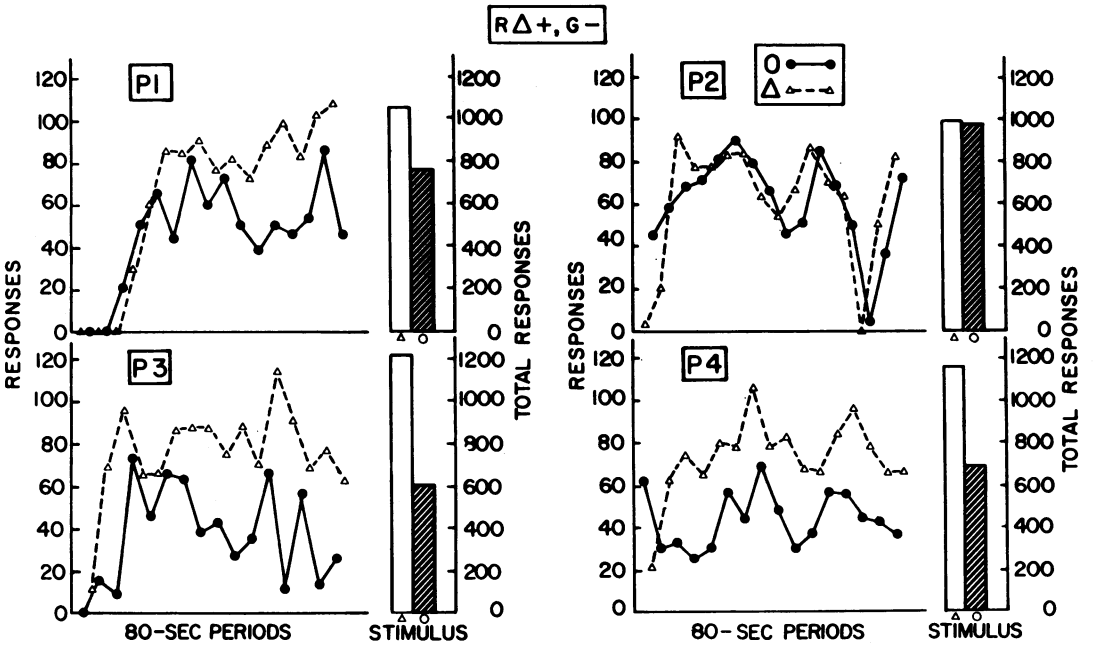

Fig. 3. Resistance-to-reinforcement data for pigeons trained on red-plus-triangle (S+) versus green (S−) discrimination (Birds 1 through 4). The left portion of each panel presents the number of responses made during successive 80-sec presentations of the white triangle and novel white circle. Bars to the right of each panel show total responses during the session as a function of stimulus presented.

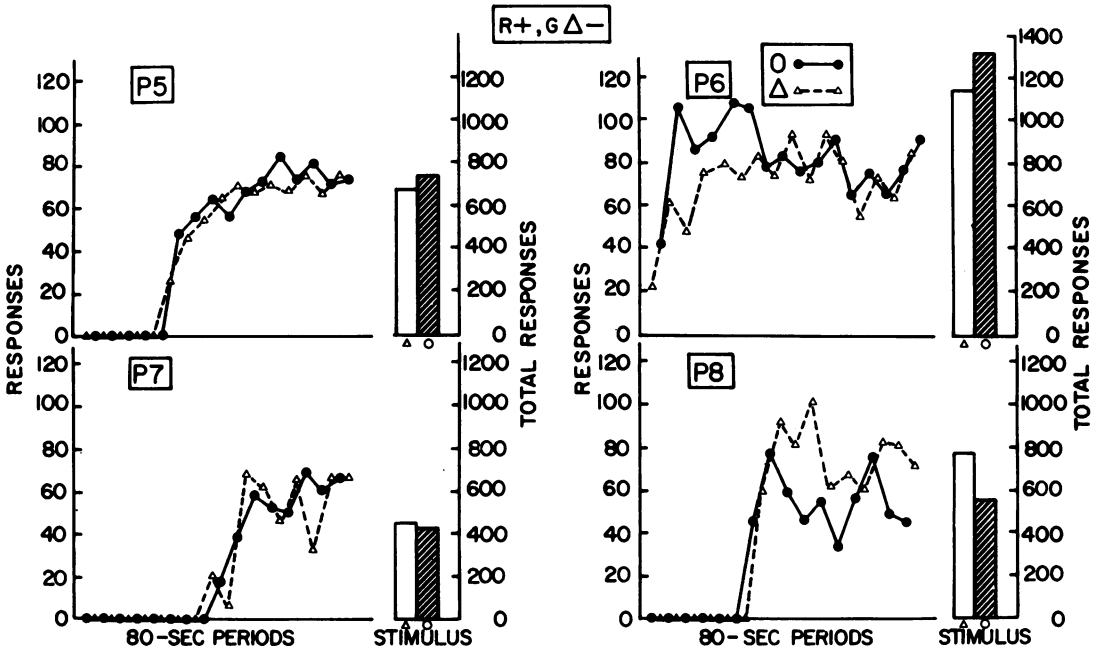

Fig. 4. Resistance-to-reinforcement data for pigeons trained on a red (S+) versus green-plus-triangle (S−) discrimination (Birds 5 through 8). The left portion of each panel presents the number of responses made during successive 80-sec presentations of the white triangle and novel white circle. Bars to the right of each panel show total responses during the session as a function of stimulus presented.

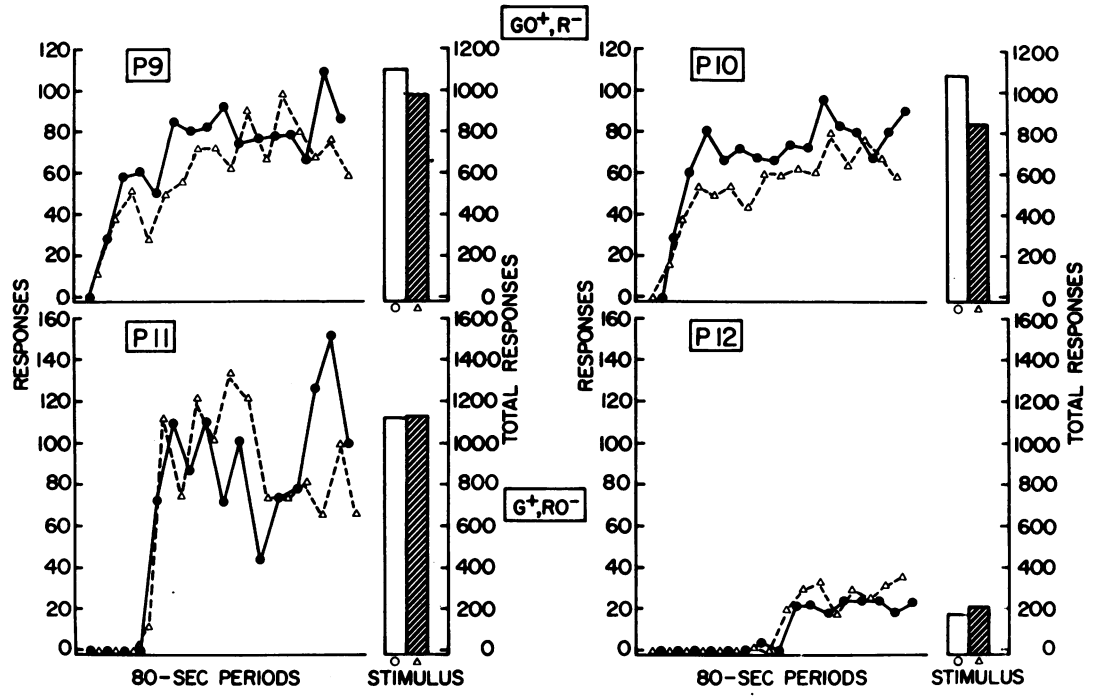

Fig. 5. Resistance-to-reinforcement data for pigeons trained on a green-plus-circle (S+) versus red (S−) discrimination (Birds 9 and 10) or on a green (S+) versus red-plus-circle (S−) discrimination. The left portion of each panel presents the number of responses during successive 80-sec presentations of the white circle and novel white triangle. Bars to the right of each panel indicate total responses during the test as a function of stimulus presented.

small and unreliable but, for Bird 8, the triangle was consistently pecked at more than the circle in the last half of the session.

Figure 5 shows the resistance-to-reinforcement data for Birds 9 through 12.

The major features of the data for Birds 1 through 8 were replicated using different stimuli. Both Birds 9 and 10 responded more to the S+ form (circle) than to the novel form (triangle). This difference emerged early in the session for both birds and was maintained across the session for Bird 10. The results for Birds 11 and 12 were inconsistent. Bird 11 responded about equally to both the S− form (circle) and the novel form (triangle), and Bird 12 pecked only slightly more at the novel form than the S− form.

In summary, all six birds trained with a positive form-color compound responded more to the S+ form than to a novel form during the resistance-to-reinforcement test. Birds trained with a negative form-color compound did not, however, consistently respond less to the S− form than to a novel form.

Discussion

The results of the attention test in Experiment 1 confirm several previously reported findings. In agreement with data by Farthing and Hearst (1970) and Wilkie and Masson (1976), pigeons trained with a positive form-color compound responded more to color than to form when each element was separately tested, indicating that color is the dominant element of such compounds. The present results also confirm Farthing and Hearst's (1970) finding that removing the form element of a positive form-color compound results in decreased responding relative to the original S+. This generalization decrement between the form-color S+ and the color element alone suggests that the form element does acquire some excitatory control. The present data and previous work also indicate that adding the form element of a negative form-color compound to a positive color produces less responding than the positive color alone (Farthing & Hearst, 1970). It is not clear from this finding, however, that the form element of an S− compound acquires inhibitory control. The reduced responding observed when an S− form is superimposed on an S+ color may be due to a simple generalization decrement caused by superimposing the triangle on the color. The resistance-to-reinforcement tests of the present study were conducted to assess these alternative interpretations.

According to the logic of the resistance-to-reinforcement test, evidence of excitatory control by form in the present study would be obtained if birds trained with a compound S+ responded more to the form element of the compound than to a novel form. Evidence of inhibitory control by form would be obtained if birds trained with a compound S− responded more to a novel form than to the form element of S−.

Regarding excitatory control by the form, all birds in the present study trained with a compound S+ responded more to the S+ form than to the novel form, although this difference was not always large (e.g., Birds 2 and 9). This result suggests that the form component of the positive compound was attended to and acquired excitatory control. With respect to inhibitory control, some birds did respond more to the novel form than to the S− form, but this difference was small and unreliable across successive stimulus presentations (e.g., Birds 5, 11, and 12). Moreover, some birds responded more to the S− form than to the novel form (e.g., Birds 7 and 8). Thus, the results provide little evidence that the S− form acquired inhibitory control and suggest that the response decrement obtained when an S− form is superimposed on an S+ color is better interpreted as an instance of stimulus generalization decrement. Note that all birds in Experiment 1 who were trained with the negative compound showed this decrement whether or not they responded more to the novel form than to the S− form during the resistance-to-reinforcement test.

One aspect of the procedure employed in Experiment 1 posed a problem for interpretation of the results. During discrimination training, S+ and S− presentations were separated by brief periods when the response key was darkened, the houselight remained illuminated, and grain was unavailable. Thus, a dark response key, in addition to specific form-color compounds, was associated with periods of nonreinforcement. Although the birds did not peck at the dark key, previous evidence shows that a stimulus differentially associated with the absence of reinforcement may acquire inhibitory properties even in the absence of pecks at that stimulus (Karpicke &

Hearst, 1975). Therefore, in Experiment 1, presentation of the form stimuli "alone" (i.e., on the darkened key) may actually have involved presentation of the form stimuli in compound with a negative stimulus whose inhibitory properties could suppress responding to the form. This problem is most pressing in the case of subjects trained with a compound S+. Experiment 2 was designed to investigate the effects of using a total blackout between S+ and S− presentations, thus eliminating the possibility that the background against which forms were presented may have acquired inhibitory control.

EXPERIMENT 2

Method

Subjects and Apparatus

Four experimentally naive female Silver King pigeons were maintained at approximately 80% of free-feeding weight throughout the experiment. Water and grit were continuously available in the home cages. The apparatus was that described for Experiment 1.

Procedure

The procedure was the same as in Experiment 1 except that during discrimination training both houselight and keylight were turned off during the 5-sec periods separating S+ and S−. All four birds were trained with a form-color compound as the positive stimulus and color as the negative stimulus, as follows: Bird 15, circle on green (S+) versus red (S−); Bird 16, triangle on green (S+) versus red (S−); Bird 17, circle on red (S+) versus green (S−); and Bird 18, triangle on red (S+) versus green (S−).

Attention tests and resistance-to-reinforcement tests were administered as in Experiment 1.

Results and Discussion

Discrimination Training

Table 1 shows the mean number and the range of responses to S+ and S− over the last five sessions of discrimination training for each bird in Experiment 2. These values fall within the range of values obtained in Experiment 1, and there were no differences systematically related to the colors used as S+ and S−. However, more responding was obtained during S+ when the circle was used as the S+ form (Birds 15 and 17) than when the triangle was used (Birds 16 and 18). Since this difference did not appear for birds trained with the circle and triangle as S+ forms in Experiment 1, it seems reasonable to conclude that it reflects individual differences in the birds' behavior, not a reliable difference in the associability of the two forms, and thus does not complicate interpretation of within-subject comparisons. At the end of discrimination training, pecking for each bird was almost exclusively confined to the stimulus compound associated with reinforcement.

Attention Test

Figure 6 shows the attention-test results for Birds 15 through 18. The major features of the data for birds trained in Experiment 1 with a positive compound stimulus were replicated. All birds pecked most at the original S+ compound. Removing the form element of the positive compound (i.e., presenting green-alone for Birds 15 and 16 and red-alone for Birds 17 and 18) resulted in decreased responding relative to the S+ compound, but the S+ color alone controlled more responding than did the S+ form (a circle for Birds 15 and 17; a triangle for Birds 16 and 18). Each bird did respond to the S+ form and pecked more at the S− color with the S+ form superimposed than at the S− color alone. Thus, the results were in agreement with those of Experiment 1 showing that, while color is

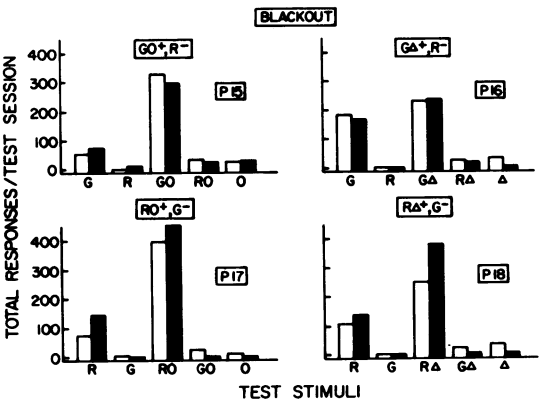

Fig. 6. Total responses recorded during each attention-test session as a function of stimulus-display for birds trained on a green-plus-circle (S+) versus red (S−) discrimination (P15), a green-plus-triangle (S+) versus red (S−) discrimination (P16), a red-plus-circle (S+) versus green (S−) discrimination (P17), or a red-plus-triangle (S+) versus green (S−) discrimination (P18).

the dominant element of a positive form-color compound, the S+ form does acquire excitatory control.

A finding of special interest concerns the number of responses for Birds 15 through 18 to the S+ form presented on a dark key compared with the number of responses to the same stimulus for birds trained in Experiment 1 with a compound S+. If, as a result of its differential association with nonreinforcement, the dark key acquired inhibitory properties in Experiment 1, then responding to the S+ form presented in compound with the dark key may have been suppressed. Since a blackout was used in Experiment 2 to separate S+ and S−, the dark key was not functionally present during periods of nonreinforcement and would not be expected to acquire inhibitory control. Thus, the S+ form presented on a dark key might be expected to produce less responding in Experiment 1 than in Experiment 2. Table 2 shows the number of responses to the S+ form during the attention-test sessions for birds trained with an S+ compound in Experiments 1 and 2. More responses generally occurred in the first test session than in the second and individual differences were apparent. However, there were no systematic differences in responding to the S+ form on a dark key between the two experiments. Therefore, there was no evidence to suggest that the darkened key acquired inhibitory control or had effects in Experiment 1 that would complicate interpretation of the data.

Resistance-to-Reinforcement Test

Figure 7 presents the results of the resistance-to-reinforcement test for Birds 15 through 18. Birds 15 and 17, for whom the circle was the S+ form and the triangle was a novel form, pecked more at the circle than the triangle. For Bird 17, this difference emerged at the outset of the test and was maintained throughout the session, but for Bird 15, the difference was slight and unreliable between successive stimulus presentations. Birds 16 and 18, for whom the triangle was the S+ form and the circle was a novel form, reliably pecked more at the triangle than the circle throughout the test. The results for Birds 15 through 18 thus confirm the finding of Experiment 1 that the form element of a positive form-color compound acquires excitatory stimulus control.

GENERAL DISCUSSION

In his original experiment on attention, Reynolds (1961) concluded that one of the elements of the positive stimulus compound gained exclusive control of responding. Further research has shown that this is not generally the case. Data by Farthing and Hearst (1970) and Wilkie and Masson (1976), as well as the results of the present experiments, show that the color element of a positive form-color compound is dominant in gaining stimulus control, but data also show that birds do at-

Table 2

Number of responses to the S+ form during the attention-test sessions for birds trained with an S+ compound in Experiment 1 and Experiment 2.

	Subjects					
	P1	*P2*	*P3*	*P4*	*P9*	*P10*
EXPERIMENT 1						
Training Stimuli[a]	R△+,G−	R△+,G−	R△+,G−	R△+,G−	GO+,R−	GO+,R−
Attention Test 1	30	33	119	57	49	11
Attention Test 2	0	5	8	0	6	26

	Subjects			
	P15	*P16*	*P17*	*P18*
EXPERIMENT 2				
Training Stimuli[a]	GO+,R−	G△+,R−	RO+,G−	R△+,G−
Attention Test 1	27	35	12	32
Attention Test 2	20	3	0	1

[a]Stimuli presented during discrimination training, red, green, white triangle and white circle, are referred to as G, R, △ and O, respectively; R△ = a compound stimulus with the white triangle superimposed upon a red background; GO = a white circle on a green background, etc. Pluses and minuses identify positive and negative stimuli. See text for details.

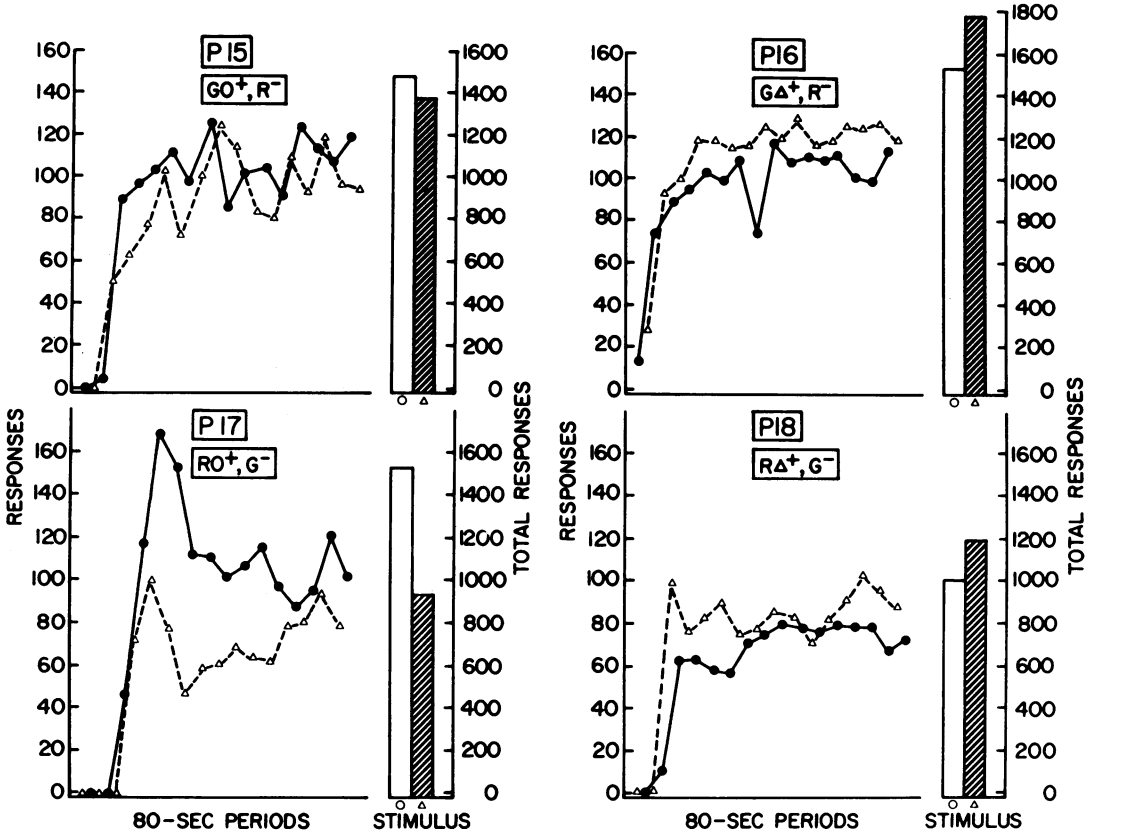

Fig. 7. Resistance-to-reinforcement data for Birds 15 through 18. The left portion of each panel presents number of responses during successive 80-sec presentations of a white circle or white triangle. Bars to the right of each panel indicate total responses during the test as a function of stimulus presented.

tend to the form element. First, data by Farthing and Hearst (1970) and the results of the present study show that removing the form element of a positive form-color compound consistently produces a generalization decrement. Second, the present results show that the birds trained with a positive form-color compound responded more to the S+ form than to a novel form in a resistance-to-reinforcement test. The relatively small differences in responding for some birds on the latter test may have been due to generalization between the two forms such that reinforcement delivered in the presence of one strengthened responding to the other. Another possibility is that responding to the S+ form on a dark key underwent some degree of extinction during the attention test preceding the resistance-to-reinforcement test.

While the available evidence indicates that the form element of a positive form-color compound gains some measure of stimulus control, the present results, together with those reported by Reynolds (1961), Farthing and Hearst (1970), and Wilkie and Masson (1976), show that the S+ form produces very little responding when tested alone. Since removing the form element from a positive form-color compound (i.e., persenting color alone) produces a reliable generalization decrement, then removing the color element (i.e., presenting form alone) should also produce a generalization decrement. Thus, the low level of responding typically produced by presenting the S+ form alone must be partially attributed to a generalization decrement induced by the change from a colored to a dark background.

Experiment I of the present study also attempted to assess inhibitory control by the form element of a negative form-color compound. It was found that superimposing the S− form on the S+ color produced less responding than did the S+ color alone. How-

ever, the resistance-to-reinforcement test provided no evidence that the S− form had acquired inhibitory control. The birds tested did not consistently respond more to a novel form than to the S− form. This result suggests that the decreased responding observed when the S− form was presented in compound with the S+ color was an instance of generalization decrement induced by the change from color alone to color-plus-form. Thus, there appears to be an asymmetry between positive and negative stimulus compounds. The form element of a positive compound stimulus does gain some excitatory control, but the form element of a negative compound stimulus apparently gains no inhibitory control.

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